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Model predictive control on irrigation canals, application on the Central Main Canal in Arizona

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As fresh water is becoming more and more expensive and scarce all over the world, proper water management is required to improve the efficiency of water distribution systems. To irrigation, more accurate and flexible systems are required, which means that the actual water supply matches the desired supply, and the water delivery meets the changing water requirements of the users. Research on irrigation canals by using automatic control are performed by the water management department of Delft University of Technology for a long time. Many classical controllers, such as Feedforward and Feedback have already been designed and applied to control water levels and flows in multiple canal reaches.

For the Central Main Canal (CMC), an irrigation canal in Eloy, Arizona, the classical control methods do not suffice. At present, the CMC is remotely-manually operated with the help of SCADA (Supervisory Control and Data Acquisition) system. The automation of these operations requires more advanced control methods. This is because 7 canal reaches are controlled only by using 6 under-short gates lying between the reaches. Also, the head gate can only be changed twice per day to adjust the flow, which means that there will be large mismatches between supply and demand. This needs an optimization technique to spread out the entire mismatch over all reaches. Also, there are limits (constraints) for each canal reach and structures, for example, each reach has upper and lower bound which may not be violated and all the gates are not allowed to move out of the water and can only pass a certain maximum flow.

In this research, a more advanced control technique, Model Predictive Control (MPC),

is proposed and tested. Its objective is to set the water level to the setpoint as close and fast as possible, and to minimize the flow changes through the gates, in order to make little adjustments to the structures and avoid tear and wear. The controller not only takes advantage of the use of feedforward (predictions of available and demanded flows) and feedback control (water level measurements), but also uses optimization to spread out the mismatch between water supply and demand and takes into account the constraints of the system. The CMC is modeled by using a numerical hydro-dynamic model, while the MPC is designed in MATLAB code.

In the model simulations, all the canal reaches can be controlled properly with the six inline gates. The inflow and outflow mismatches are spread to each reach and no violation of limits occur. Finally, farmersą́ demands can be fully met.